AN ANALYSIS OF THE EFFECTIVENESS OF COMPUTER ASSISTED INSTRUCTION IN GENERAL CHEMISTRY AT AN URBAN UNIVERSITY

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The science-major General Chemistry sequence offered at the University of Houston has been investigated with respect to the effectiveness of recent incorporation of various levels of computer technology. As part of this investigation, questionnaire responses, student evaluations and grade averages and distributions from up to the last ten years have been analyzed and compared. Increased use of web-based material is both popular and effective, particularly with respect to providing extra information and supplemental questions. Instructor contact via e-mail is also well-received. Both uses of technology should be encouraged. In contrast, electronic classroom presentation is less popular. While initial use may lead to improved grades and retention, these levels decrease quickly, possibly due to a reduction in instructor spontaneity.

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

The incorporation of computer-based technology into the General Chemistry curriculum is an activity that has received a great deal of attention in the last twenty-five years. Initially, the focus was on experimental simulation and rather primitive quizzing software. Over the last decade, however, the development of more and more powerful laptop computers together with the incredible growth of the internet have meant that computers are now firmly entrenched as a primary teaching tool.

There is a wide spectrum of applications in use, the extent of which depends upon the institution, student body and individual faculty preference. Some schools have progressed to the stage where each student brings a computer to class, and the entire lesson is taught by a combination of computer-based slides and the internet. At such schools, homework and even testing are entirely web-based. At the other end of the spectrum are classrooms in which the instructor writes on the chalkboard and no computer-based activities outside the classroom are required.

Most of the applications have been developed and refined at schools in which every student may be required to own a computer and with fairly homogeneous student bodies. Accordingly, therefore, most of the literature available on the use and effectiveness of different technologies have focused on such institutions. The University

of North Texas (UNT), however, is not such an institution. The student body is rather non-traditional, consisting of a high proportion of part-time, commuter and older students. This had led to the perception, at least, that many may not have ready access to computers away from the campus, while others are not sufficiently "computer-literate" to take full advantage of technology. Accordingly, the potential benefits and effectiveness of using technology at UNT may not reflect those observed and reported for different types of university.

An institution that is similar to UNT is the University of Houston (UH). UH is a large urban university, with an average enrollment that varies between 31,000 and 34,000 students. The student body is very diverse. Students range in age from 16 to 60+ with average age usually being in the mid-20's. Most (approximately 90%) work at least 15 hours a week and do not live on campus. The average SAT of incoming students is close to 1100. All of these characteristics are very similar to those of the student body at UNT. It is reasonable, therefore, to expect that the results of any study of UH students would be applicable to UNT.

1.2 General Chemistry at UH

The UH chemistry department teaches some form of General Chemistry to approximately 2,500 different students each year. These students take one of four different sequences, three of which correspond exactly to sequences offered at UNT: the honors sequence, CHEM 1331-H/1332-H (equivalent to UNT 1412/1422), the science majors course, CHEM 1331/1332 (equivalent to UNT 1410/1420), and a course for non-

science majors, CHEM 1301 (equivalent to UNT 1350). The fourth one offered at UH is a one-semester course designed for certain engineering majors (mechanical, electrical etc). In this thesis, I shall focus on the science majors sequence – CHEM 1331 and 1332.

The courses of this two-semester sequence are offered in the Fall and Spring semesters, as well as during the summer. While they have fluctuated in recent years, the usual enrollments are as shown in Table 1-1.

Table 1-1. Average Enrollments in CHEM 1331/1332 at UH

Semester	CHEM 1331	CHEM 1332
Fall	1000	200
Spring	500	700
First half of Summer	160	Not offered
Second half of Summer	Not offered	150

Given the different nature of the summer classes, these will not be examined at all in this thesis.

The courses during both the on-semester (1331 in the Fall and 1332 in the Spring) and off-semester (1331 in the Spring and 1332 in the Fall) sequences are usually taught by full-time Faculty in "sections" that range in size from 50 to 320 students (only the Fall 1332 class is not multiple-section). In order to achieve consistency between sections, common exams are given to all sections at the same time (5:30 to 7:00 pm on Friday

evenings!). Final grades are usually based on three exams (20% each) and a comprehensive final (40%) and the same grading scale is used (Table 1-2). At the end

Table 1-2. Common Grading Scale for General Chemistry Sections

Score	Letter Grade	Score	Letter Grades
>89	A	60-64	C
85-89	A-	55-59	C-
80-84	B+	52-54	D+
75-79	B	48-51	D
70-74	B-	46-47	D-
65-69	C+	<46	F

of each semester, the faculty meet as a group to decide whether any "curve" is appropriate. This is usually based upon the number of questions (if any) that were answered correctly by less than 20% of the students. This number is rarely more than two. In addition, there is an unwritten guideline that individual faculty members can make their own decisions about grades that are one point away from the next letter grade.

Both the section size and uniformity in testing and grading are different between UH and UNT. It is this difference, however, that has led to the development of the work in this thesis. The common exams and grading scale mean that one section in a particular semester may be readily compared to another. Use of the same scale and

approach every year means that one year may be compared to a different one. Finally, the larger section size increases the statistical significance of any observations made.

1.3 Technology in the General Chemistry Program at UH

Certain General Chemistry instructors at UH have long incorporated technology into the program. These efforts have been particularly concentrated since 1995. "Technology" is a wide-reaching word. The specific applications to be discussed in this thesis may be divided into three categories: incorporation into the classroom, use of the web, and distant-instructor interaction.

Classroom

Several faculty at UH use computer lectures. These are delivered primarily via PowerPoint™ (henceforth, referred to as simply PowerPoint or PP) presentations. The lecture is written on a series of slides, saved in PowerPoint format and loaded onto a laptop or a computer permanently fixed in the classroom. The output is projected onto a screen. In addition, "real-time" calculations and extemporaneous additions to the notes can be made using a "white board," the output of which is also projected to the screen. Generally, one can equate the PowerPoint presentations to sophisticated use of overhead transparencies. However, use of PowerPoint has extra advantages, allowing slides to be mixed with animations and video clips. Some of the video clips are substitutes for in-class demonstrations, while the animations have no real analogy in traditional teaching methodology. The use of the “white boards” is exactly analogous to use of a chalkboard

– the advantage of using it with the computer presentation is that it eliminates the need to switch student attention between screen to chalkboard. For the remainder of this thesis, computer presentations will be referred to as PowerPoint for convenience, even though there are usually more features utilized than purely slides.

Web Materials

Most of the faculty utilize the web to differing extents. The different ways may be sub-divided into "notes," "course information," "extra resources," and testing. Two commercial web suites have been used in attempts to organize web use – “IntraKal”™ in the 1998/1999 academic year and WebCT™ since Fall 2000.

Notes

Generally, the PowerPoint™ presentations used in class are placed "on the web" and made available to students. Students are encouraged to "download" these slides before coming to class and use them as a foundation for their note-taking. In addition, if a student misses class, he/she has access to the material covered. This is analogous to instructors who provide copies of overhead transparencies to the students, although there is the advantage that students who lose their note packet can simply download another.

Course Information

Many instructors post the course syllabus, test dates, and class and review session information on the web. Again, this represents primarily a substitution for old-fashioned

hard copy handouts but also provide a remedy for the traditional "I lost my syllabus" excuse.

Extra Resources

Several instructors have posted review sheets, extra questions, and old exams to the web. These may either be in downloadable form or presented as HTML files. This use of technology is a substitution for extra class handouts, so essentially represents only a saving of photocopying-related time and money.

In addition, most publishers of textbooks now provide web assistance to the students. This is usually free, but requires purchase of the book to obtain access information. These web-sites contain a combination of extra information (such as computer animations) and supplemental questions (interactive quizzes, for example) in addition to repeating much of the book. These uses of technology will not be considered in this work, which aims to focus on applications that are developed by the individual instructor. (This statement also applies to the CD's provided with most textbooks).

Interaction with Instructor

E-mail represents a means by which students may gain access to the instructor – in addition to office hours and telephone contact. Most instructors at UH strongly encourage students to use this form of communication.

In addition, several experiments to provide "virtual office hours" have been attempted. These are essentially like the "chat-rooms" familiar to Yahoo and AOL users

everywhere. Some software that enables the instructors to write calculations and draw structures has also been incorporated. These attempts have not been consistently applied to an entire class, however, so will not be examined for effectiveness.

Finally, video-streaming of lectures has been used by one instructor in one class for two years. There have been so many problems with the hardware associated with this, as well as the problems students have with downloading the stored data, that it has not been consistently used. Again, except for the occasional comments, this will not be a focus of this thesis.

1.4 Goal of the Thesis

There are few investigations of the effectiveness of using various forms of technology to teach General Chemistry to a student body such as that at UNT. In this thesis, I aim to carry out such an investigation. Specifically, I will examine the General Chemistry program at UH, which offers essentially the same courses to a very similar student body. In particular, student comments, evaluations and grades for the last several years in the science-majors sequence will be compared to determine whether extensive incorporation of different types of technology has resulted in any significant changes in student attitudes and/or performance. Suggestions based on the results of this examination will be made concerning the different ways to incorporate technology into the program.

CHAPTER 2

STUDENT OPINIONS

2.1 Introduction

In order to determine subjectively the effects of technology use in class, various levels of student questionnaires have been used. Some of these were given specifically for this project, while some were developed by certain instructors and the results generously shared. In addition, the usual faculty evaluations taken at the end of each semester have been analyzed.

The results have been separated into three categories – student opinions before exposure to the technological applications, student responses to specific questions at the end of a semester, and analysis of faculty evaluations.

2.2 "Semester Start Questionnaires"

A twelve-question survey of students' attitudes to computer use (Table 2-1) has been given to three classes over four years at the start of the semester (before any significant instruction): 1332 in Spring 1998 (121 responses), 1332 in Spring 2000 (118 responses), 1331 in Fall of 2001 (260 responses.) The goal of this survey is to determine how open students are to the use of technology in the classroom.

The results are presented in Tables 2-2 (Questions 1 through 6) and 2-3 (Questions 7 through 12).

Table 2-1. " Semester Start" Questionnaire

Question	**Possible Answer**
General Computer Questions	
1. Do you have a computer at home?	Yes or No
2. Do you use e-mail?	A lot, sometimes, never
3. Do you use the web?	A lot, sometimes, never
4. How computer literate are you?	Very, somewhat, not
In-class Use	
5. Would you like class to be presented using PowerPoint or other computer tools?	Yes, no, don't know
6. How many of your other classes are presented using PowerPoint or other computer tools?	A lot, some, none
Web Use	
7. Would you like class notes to be posted on the web?	Yes, no, don't know
8. Would you like reviews to be posted on the web?	Yes, no, don't know
9. Would you like tests/quizzes to be given on the web?	Yes, no, don't know
10. How much is the web used in your other classes?	A lot, sometimes, never
General Conclusion	
11. Would you like most of your education to be computer based?	Yes, no, don't know
12. Would you like some of your education to be computer based?	Yes, no, don't know

Table 2-2. Results for "Semester Start" Questionnaire, Questions 1-6

Question	Possible Answer	Spring 1998	Spring 2000	Fall 2001
1	Yes	82%	86%	95%
	No	18%	14%	5%
2	A lot	54%	56%	56%
	Sometimes	34%	35%	38%
	Never	12%	9%	5%
3	A lot	51%	62%	63%
	Sometimes	42%	35%	35%
	Never	7%	3%	2%
4	Very	43%	36%	38%
	Somewhat	54%	60%	58%
	not at all	3%	4%	5%
5	Yes	0%	1%	7%
	no	98%	98%	90%
	don't know	2%	1%	3%
6	A lot	0%	5%	2%
	some	54%	90%	25%
	none	46%	5%	73%

Table 2-3. Results for "Semester Start" Questionnaire, Questions 7-12

Question	Possible Answer	Spring 1998	Spring 2000	Fall 2001
7	Yes	79%	87%	92%
	no	16%	12%	4%
	don't know	5%	1%	4%
8	Yes	84%	95%	99%
	no	12%	5%	0%
	don't know	4%	0	1%
9	Yes	44%	39%	4%
	no	47%	58%	93%
	don't know	9%	3%	2%
10	A lot	4%	11%	13%
	Sometimes	42%	56%	51%
	never	54%	33%	36%
11	Yes	3%	3%	3%
	no	91%	96%	94%
	don't know	6%	1%	3%
12	Yes	42%	50%	71%
	no	55%	47%	27%
	don't know	3%	3%	2%

The responses may be divided by question-type. The first four questions deal with student attitudes towards and experience with computers. The data for these questions are shown in Figure 2-1.

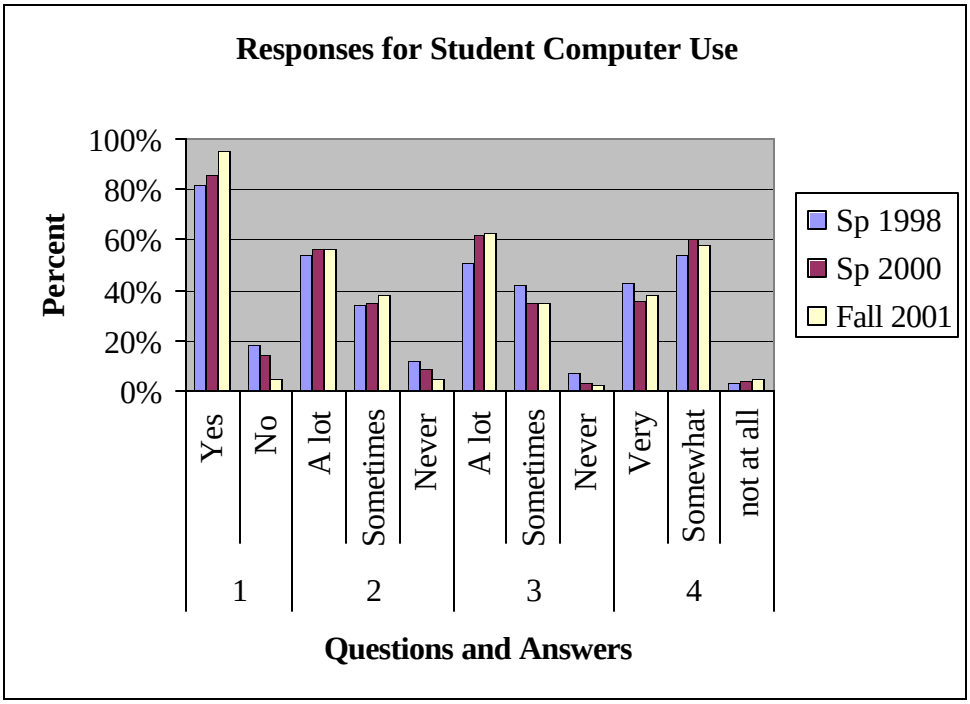


Figure 2-1. "Semester Start" Questionnaire responses dealing with student computer use.

The responses to these four questions reflect the increase in computer use in society generally over the last four years. The proportion of students who have a computer at home (Question 1) has increased from 82 to 95%. This observation is significant in that a frequent excuse for not using computer applications in class is that students might not have ready access to computers. Obviously, such an excuse is no longer valid. Student use of computers has also grown as expected during that time. The

proportion of students who do not use e-mail (Question 2) has more than halved over the course of the investigation from 12% to 5%. A larger decrease is seen in the number of students who do not use the web at all (Question 3), from 7% to 2%. Interestingly, web use appears to have grown more than e-mail use. Finally, students' perceptions of themselves as to whether they are computer-literate has stayed fairly constant – a slight majority considering themselves to be somewhat computer-literate with the vast majority of those remaining, very literate. The percent of students who consider themselves not at all literate is small in all three years, although a slight increase is observed from 3 to 4 to 5%.

When considered as a whole, these data suggest that students are very computer-oriented, with only a tiny minority still not using them to any extent. Accordingly, therefore, being told of any application of computer technology to class should not distress the students.

The nature of the application is the subject of the next two categories of questions – Questions 5 and 6, which deal with PowerPoint applications, and Questions 7 through 10, which deal with web use in the class. The data for these two categories are shown in graph form in Figures 2-2 and 2-3.

The responses to Question 5 would appear to be rather emphatic – while students are not as opposed to classroom PowerPoint presentations in the most recent survey as in the past, a massive 90% still do not like them. There is no doubt that this result is not an entirely representative one. As will be discussed in a later section of this thesis, students are generally polarized with respect to PowerPoint classes – they like them or they hate

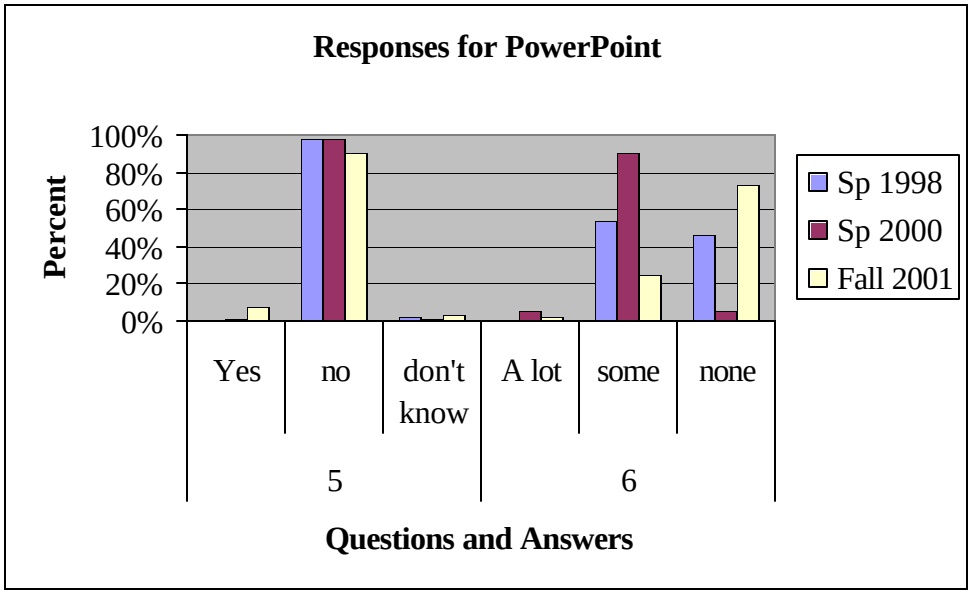


Figure 2-2. "Semester Start" Questionnaire responses dealing with classroom PowerPoint presentations.

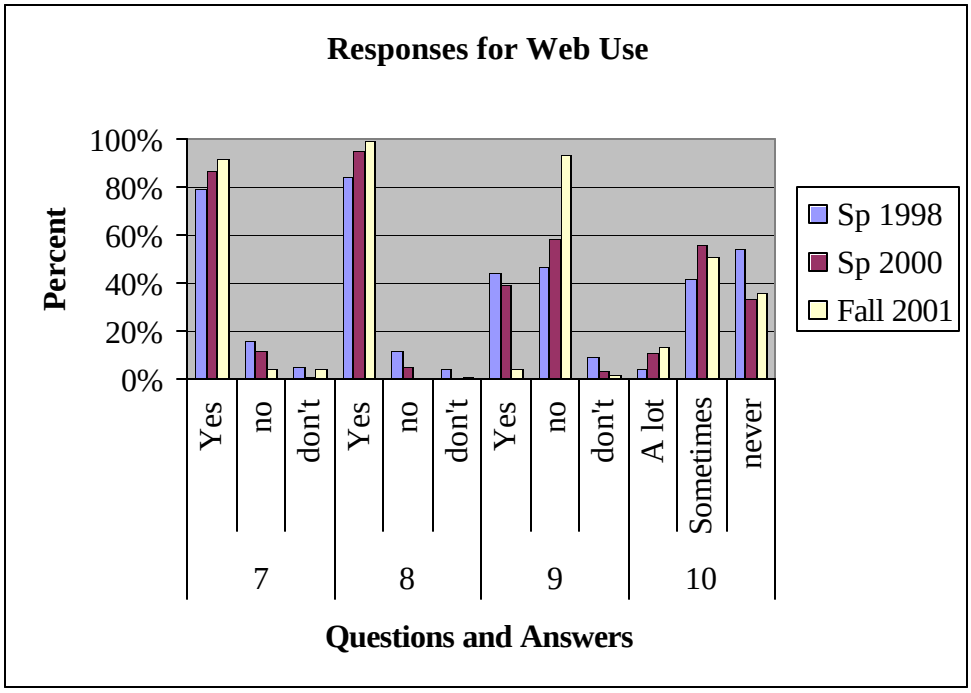


Figure 2-3. "Semester Start" Questionnaire responses dealing with web use.

them. It is well known which instructors do and do not use PowerPoint. Accordingly, therefore, many students will select their section based on their choice of instruction method. The sections in which these "Semester Start" questionnaires have been given have been exclusively "non-PowerPoint." Regardless, the fact that so many students who profess to be at least somewhat computer-literate are so averse to the method is a result worth remembering.

This student aversion may have something to do with the rather startling result apparent from the responses to Question 6. Two years ago, ninety percent of student respondents said that they had had at least one class that used PowerPoint. Now, nearly three-quarters of students have no such classes. While some of this may be due to the fact that the previous surveys were taken in classes that consisted predominantly of second-semester Freshmen while the most recent was a 1331 class, which contained a large proportion of first-semester Freshmen, it is unlikely that this is the cause of all of the difference. In other words, it is possible that, after an initial surge of enthusiasm for using PowerPoint, interest has waned somewhat and some instructors are reverting to the "old-fashioned ways."

This trend is not reflected in the responses to questions dealing with web use in the classroom. As shown in the responses for Question 10, the proportion of students who say that the web is used "a lot" in their other classes has more than tripled, from 4% to 13%, while the number who say that its is never used has dropped from 54% to a value in the thirties. One can attribute the slight increase from 33 to 36% between Spring 2000 and Fall 2001 to the relative "age" of the students, mentioned above.

The first three questions in this category address three common ways in which the web may be used in a class – for notes, extra material such as reviews or for administering exams.

Not surprisingly, these responses have changed as student web-use has changed. Thus, the proportion of students who favor web-posting of material useful for them has risen from the low 80's to the mid to high 90's. It is rather amusing to note the opposite effect for the responses concerning web-administered exams (Question 9) which have changed from essentially a split-vote in Spring of 1998 to an almost unanimous "no" vote. This is presumably due to bad experiences with computer testing.

That the students are generally open to selective incorporation of computer technology into the classroom is shown by the responses to Questions 11 and 12 (Figure 2-4). While students have been consistently opposed to most or all of their education

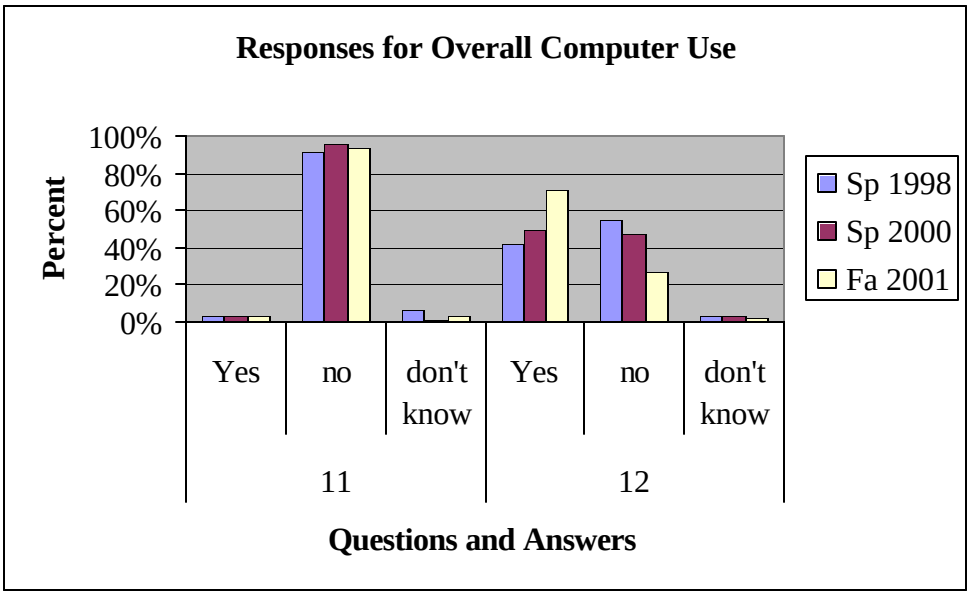


Figure 2-4. "Semester Start" Questionnaire responses dealing with overall computer use.

being computer based, the proportion who favor some technology has increased steadily from a minority of 42% to a strong majority of 71%.

Taken as a whole, these data reflect a student body that is quite familiar with computers and welcomes their selected incorporation into the classroom.

2.3 Student Responses to Computer Use at the End of the Semester

The section above focused on students beginning the semester, asking about their experience with and attitudes towards computers. The next stage is to investigate student opinions at the end of the semester. The effectiveness of various different aspects of the technology was the subject of questionnaires given by various instructors after different semesters. The results of these are collated and normalized in Table 2-4 and are plotted in Figure 2-5. The responses are "graded" as 5 for very effective or useful through 1 being very unhelpful or ineffective (different wording was used in different surveys).

Examination of the data shown in Table 2-4 and Figure 2-5 show some similarities to the initial survey responses discussed above. The decline in popularity of PowerPoint presentations is again apparent. While the class polarization concerning this technology should again be mentioned, it should also be stressed that the students in these sections knew that PowerPoint would be used. In other words, if the pre-instruction data were skewed towards the "anti-PowerPoint" group, the data here should be skewed towards the "pro" group."

As students become more familiar with the web, they obviously become more open to and appreciative of its use in class. Thus, posting of class notes and review

Table 2-4. Student Evaluations of the Effectiveness of Different Applications (Percent Responses)

Technology	Semester[1]	5	4	3	2	1	Mean[4]
PowerPoint	F 97	78	18	2	2	2	4.74
lectures	F 99	55	20	6	2	17	3.94
	S 01	30	23	25	6	16	3.35
Notes on	F 97	63	28	3	6	0	4.48
Web	F 99	60	25	13	2	0	4.43
	S 01	59	25	14	1	0	4.41
	F 01[2]	70	22	7	1	0	4.61
Reviews on	F 97	67	20	13	0	0	4.54
Web	F 99	77	15	8	0	0	4.69
	S 01	83	10	7	0	0	4.69
	F 01[2]	88	11	1	0	0	4.87
Class	F 97	35	24	35	3	3	3.85
information	F 99	34	34	29	3	0	3.99
on Web	S 01	47	31	18	3	1	4.19
Web Tests	F 01[2,3]	77	23	0	0	0	4.77
E-mail with	F 97	11	20	57	5	4	3.2
instructor	F 99	66	30	4	0	0	4.62
	S 01	95	4	1	0	0	4.94
	F 01[2]	97	3	0	0	0	4.97

Notes:

1 F short for Fall; S short for Spring

2 Taken after 8 weeks of the semester

3 Tests offered on web as “make ups.”

4 Weighted mean score, defined as S(score x fraction of responses)

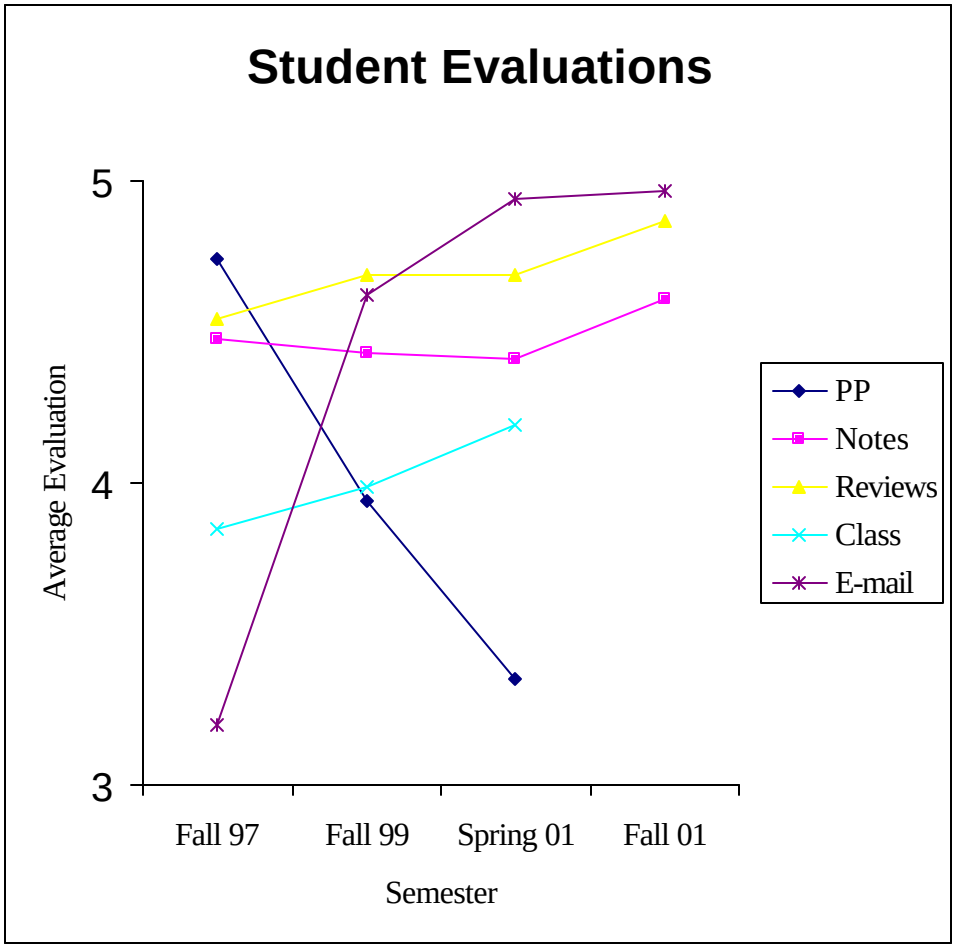


Figure 2-5. Student responses to application-specific questionnaires.

sheets has become more favored over time. It is interesting to note the positive numbers associated with posting simply class information [syllabus, news etc]. The most dramatic increase in student approval is associated with e-mail. In 1997, students were essentially ambivalent about the technology. In 2001, most of them find it extremely useful. This increase is much more dramatic than the change in general student e-mail use discussed above.

Finally, in contrast to the enormous aversion students reported to computer quizzes or tests at the start of the semester, the perception to the ones offered this semester as "make-up" exams is very positive. Most of these differences can be ascribed to student appreciation of the opportunity to make up exams. In other words, judicious use of technology is much more appealing to students.

2.4 Overall Student Evaluations

At the end of each semester, each class is asked to evaluate the instructor using a standard set of questions. While these evaluations do not specifically address the use of technology, they have been included in this study as (a) they are administered to all students in each section every semester so provide a continual means of assessing the progress of the program and (b) they provide information that may be used to examine the effect of the instructor's general popularity on the perception of technology, allowing a degree of "normalization" to the data.

The current evaluation instrument is reproduced in Table 2-5. It consists of 13 questions, to which the student responds with "Strongly disagree" through "Strongly

Table 2-5. Faculty Evaluation Instrument Used From the Fall Semester, 1997

1.	The instructor is prepared for class.
2.	The material was presented in an effective manner with respect to style, order and clarity
3.	The instructor appeared knowledgeable in the subject area.
4.	The instructor was enthusiastic about the material
5.	The importance of the subject matter and the goals of the course were emphasized.
6.	The instructor provided sufficient aid, help or clarification when necessary.
7.	Overall, the instructor was an effective teacher.
8.	The instructor was accessible outside of class.
9.	The course was reasonably paced.
10.	The examinations and quizzes were fair representations of the material covered.
11.	Grading was done fairly.
12.	The results of exams, quizzes and other evaluative material were made available to students in a timely manner.
13.	I was motivated to take this class.

Agree." The questions are worded such that a positive response is agreement. The responses are quantified by assigned numerical values of 1 through 5 to the possible answers, 5 being "best." The questions of particular relevance are Question 2 ("The material was presented in an effective manner with respect to style, order and clarity") and Question 7 ("Overall the instructor was an effective teacher). In addition, the overall average will also be considered. While the main focus of this section will be on evaluations taken since the Fall semester of 1997, some data will be used from previous semesters. Before 1997, a different evaluation instrument with fewer questions was utilized. This is shown in Table 2-6.

Table 2-6. Faculty Evaluation Instrument Used Prior to the Fall Semester, 1997

1.	I had a strong desire to take this class
2.	The instructor presents the material in a clear and understandable way.
3.	The instructor encourages student participation and welcomes questions and discussion.
4.	The instructor is willing to give students individual assistance outside class.
5.	Grading is fair.
6.	The materials and procedures are well-organized.
7.	I rate this course excellent (5) to poor (1).
8.	I rate the effectiveness of the instructor excellent (5) to poor (1).

The results of these evaluations will be examined in several different ways. First, the evaluations for all sections of 1331 and 1332 since the Fall semester of 1997 are listed in Tables 2-7 and 2-8, respectively. Rather than listing these by instructor names, the evaluations are categorized by method of class presentation – PowerPoint (PP) or not.

The responses for "Question 2" are plotted in Figures 2-6 and 2-7, respectively. There are few conclusions that can be drawn from this overall data. It could be argued that, while the PowerPoint users are not the instructors with the highest evaluations, neither are they the worse. The PowerPoint evaluations are much more closely packed that the non-PowerPoint. However, whether this is a reflection of the effectiveness of the method (i.e., using PowerPoint "normalizes" the quality of the presentation), it could just as well be linked to the quality of instructors. In addition, there is little to indicate the effectiveness of any other application of technology.

A much more reasonable approach is to examine the evaluations for individual faculty members to investigate what effect, if any, changes made in the utilization of technology had on the evaluations. The evaluations of five instructors will be examined:

Instructor A taught 1331 or 1332 from Fall 1994 through Fall 1997 (with a couple of semesters away). He switched to PowerPoint presentations in Spring, 1995. In Fall 1997, he spearheaded the purchase and installation of a "white board" for presentation of extra notes and calculations during class.

Instructor B taught 1331 from Fall 1994 through the present. He began to use PowerPoint presentations in Fall, 1995. In addition, he began to post material on the web

Table 2-7. Student Evaluation Data for 1331 Sections Since 1997

Semester	Presentation Method[1]	Question 2	Question 7.	Overall Average
Fall 1997	PP	3.75, 4.42	3.31, 4.45	3.75, 4.26
	Non-PP	4.93, 4.93, 3.65	4.92, 5.00, 3.38	4.74, 4.83, 3.77
Spr. 1998	PP	4.15	4.06	4.13
	Non-PP	3.97	3.83	3.85
Fall 1998	PP	3.41, 3.42	3.22, 3.21	3.67, 3.71
	Non-PP	4.93, 3.77, 2.92	4.94, 3.77, 2.86	4.81, 3.94, 3.38
Spr. 1999	PP	4.08, 3.27	4.03, 3.24	4.10, 3.56
Fall 1999	PP	4.00, 3.89, 3.66	3.71, 4.00, 3.33	4.08, 4.23, 3.74
	Non-PP	4.91	4.96	4.83
Spr. 2000	PP	3.43	3.18	3.67
	Non-PP	4.71	4.82	4.66
Fall 2000	PP	3.62, 4.08	3.49, 3.72	3.91, 4.09
	Non-PP	4.93	4.97	4.89
Spr. 2001	PP	4.23	4.07	4.19
	Non-PP	3.14	2.99	3.32

[1] PP = PowerPoint

Table 2-8. Student Evaluation Data for 1332 Sections Since 1997

Semester	Presentation Method[1]	Question 2	Question 7	Overall Average
Fall 1997	Non-PP	4.59	4.51	4.39
Spr. 1998	PP	3.61	3.57	3.95
	Non-PP	4.93, 3.35, 2.20	4.96, 3.33, 2.00	4.72, 3.68, 3.09
Fall 1998	Non-PP	4.91	4.92	4.87
Spr. 1999	PP	3.89	3.94	4.10
	Non-PP	4.98, 3.33, 2.60	4.98, 3.67, 2.75	4.88, 3.85, 3.04
Fall 1999	PP	3.47	3.44	3.76
Spr. 2000	PP	3.59	3.82	3.66
	Non-PP	3.95, 4.87	3.90, 4.93	3.81, 4.81
Fall 2000	PP	3.62	3.46	3.75
Spr. 2001	PP	4.02	3.89	4.03
	Non-PP	4.83, 3.33	4.86, 3.58	4.81, 3.70

[1] PP = PowerPoint

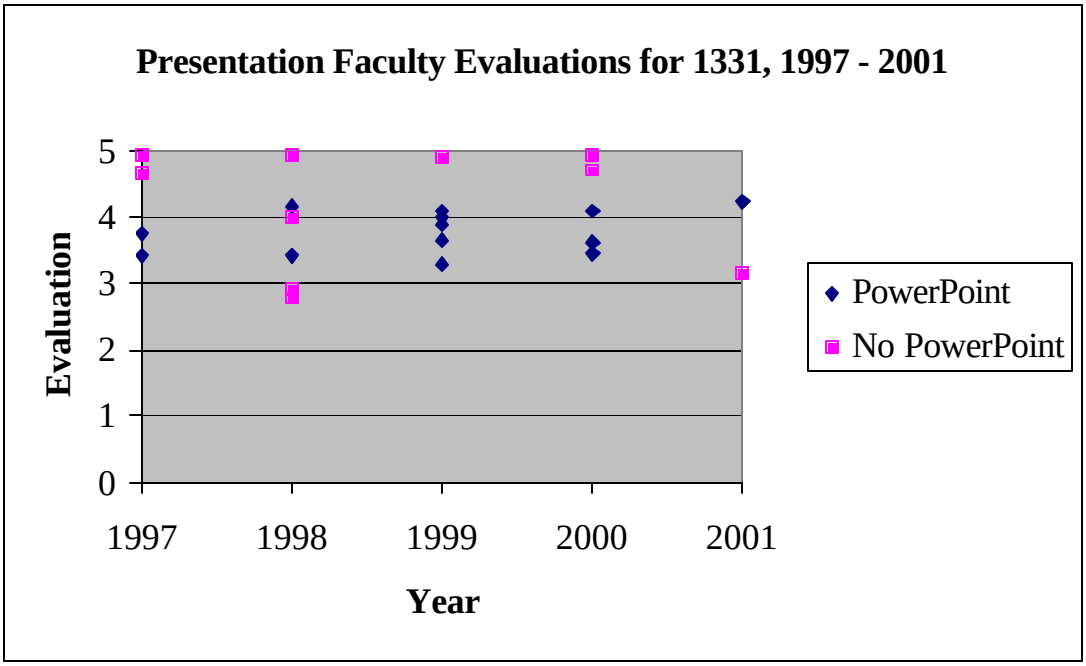


Figure 2-6. Scatter Diagram showing the "Presentation" evaluations for 1331.

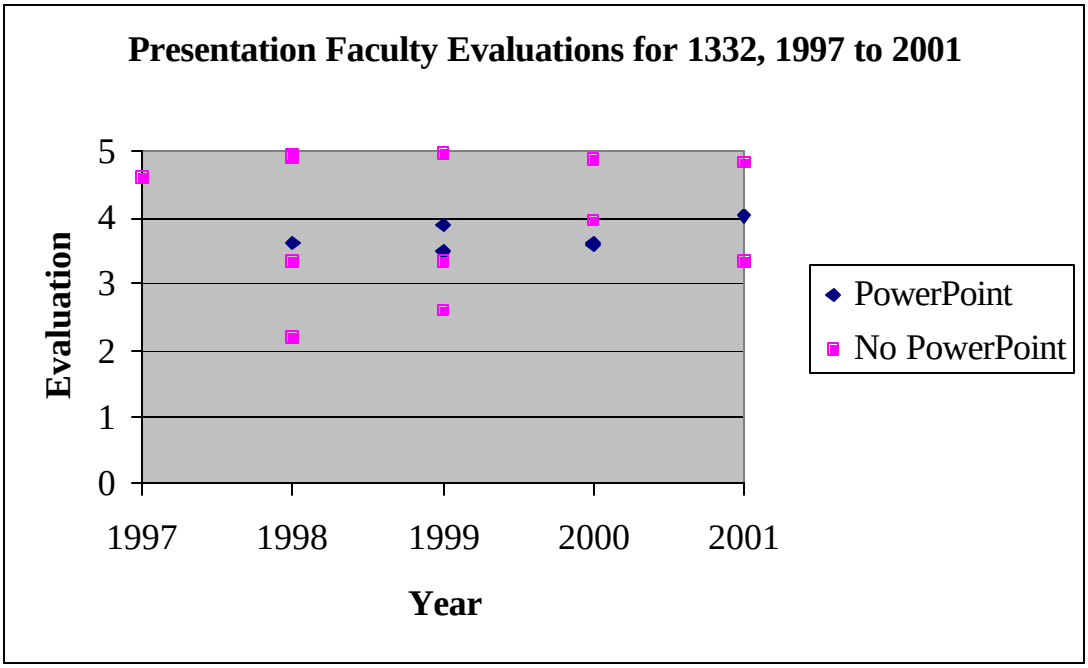


Figure 2-7. Scatter Diagram showing the "Presentation" evaluations for 1332.

sporadically until Spring 2001, when he used WebCT extensively in the class (a pilot attempt was made in Fall of 2000 that ran into many technological problems).

Instructor C taught 1332 from Spring 1998 through the present. He used PowerPoint presentations immediately, and incorporated web materials each semester.

Instructor D taught 1332 for two semesters. During the first, he used overhead presentation; in the second he switched to PowerPoint. He also made extensive use of web materials during the second semester.

Finally, **Instructor E** has taught 1332 since Spring 1998. He does not use PowerPoint but made extensive use of web postings in the Fall 1998 and Spring 2001 semesters.

The evaluations for these instructors are listed in Tables 2-9 through 2-13, respectively. The column labeled "Presentation" contains the responses to Question 2 on each of the two different evaluation instruments; the column labeled "Overall" contains the responses to Question 7 on the current instrument (used since Fall 1997, Table 2-5)

Table 2-9. Evaluation Scores for Instructor A

Semester	Presentation	Overall	Average
Fall 94	4.26	4.41	4.13
Spring 95	4.44	4.56	4.16
Spring 96	4.62	4.54	4.42
Fall 96	4.57	4.69	4.34
Spring 97	4.32	4.53	4.12
Fall 97	4.42	4.43	4.26

Table 2-10. Evaluation Scores for Instructor B

Semester	Presentation	Overall	Average
Fall 94	4.00	3.87	3.82
Spring 95	3.04	2.90	3.20
Fall 95	3.63	3.74	3.62
Spring 96	3.86	3.83	3.78
Fall 96	3.70	3.80	3.80
Fall 97	3.75	3.31	3.75
Spring 98	4.15	4.06	4.13
Fall 98	3.41	3.22	3.67
Note 1	3.42	3.21	3.71
Spring 99	4.08	4.03	4.10
Fall 99	4.00	3.71	4.08
Note 1	3.66	3.33	3.74
Spring 00	3.43	3.18	3.67
Fall 00	3.62	3.49	3.91
Note 1	4.08	3.72	4.09
Spring 01	4.23	4.07	4.19

Note:

1 Instructor B taught two sections of 1331 in the Fall semesters of 1998 through 2000.

Table 2-11. Evaluation Scores for Instructor C

Semester	Presentation	Overall	Average
Spring 98	3.61	3.57	3.95
Spring 99	3.89	3.94	4.10
Fall 99	3.47	3.44	3.76
Fall 00	3.62	3.46	3.75

Table 2-12. Evaluation Scores for Instructor D

Semester	Presentation	Overall	Average
Spring 00	3.59	3.82	3.66
Spring 01	4.02	3.89	4.03

Table 2-13. Evaluation Scores for Instructor E

Semester	Presentation	Overall	Average
Spring 98	4.93	4.96	4.72
Fall 98	4.91	4.92	4.87
Spring 99	4.98	4.98	4.88
Spring 00	4.87	4.93	4.81
Spring 01	4.93	4.86	4.81

and Question 8 on the old survey (Table 2-6). Average is the average score taken over all 13 (new questionnaire) or 8 (old questionnaire) questions.

It is always risky to try to use student evaluations for serious comparison purposes as so many other factors come into play – class time, results of recent exam(s), timing of recent exam(s), etc. and the data here provide mixed impressions if interpreted too closely. There are, however, some general points that can be discerned.

The data for Instructor A are plotted in Figure 2-8. Two increases in the numbers that correspond to a change in presentation may be observed – for Spring of 1995 (changed to PowerPoint) and Fall of 1997 (incorporated use of "white board.") It is interesting to note that the trends for "Presentation" and "Average" are virtually identical, while the trends in his "Overall" evaluation appear to be "delayed" by a semester. In other words, he is focused on "making the change" to the possible detriment of his overall classroom performance.

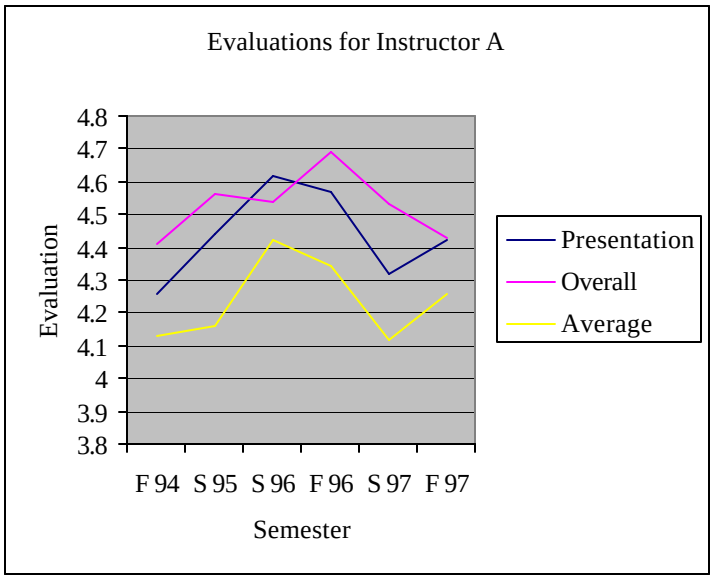


Figure 2-8. Line graph showing pertinent evaluations for Instructor A.

The data for Instructor B (plotted in Figure 2-9) are really too random to make many generalizations, although a few striking features emerge. The students in the Fall

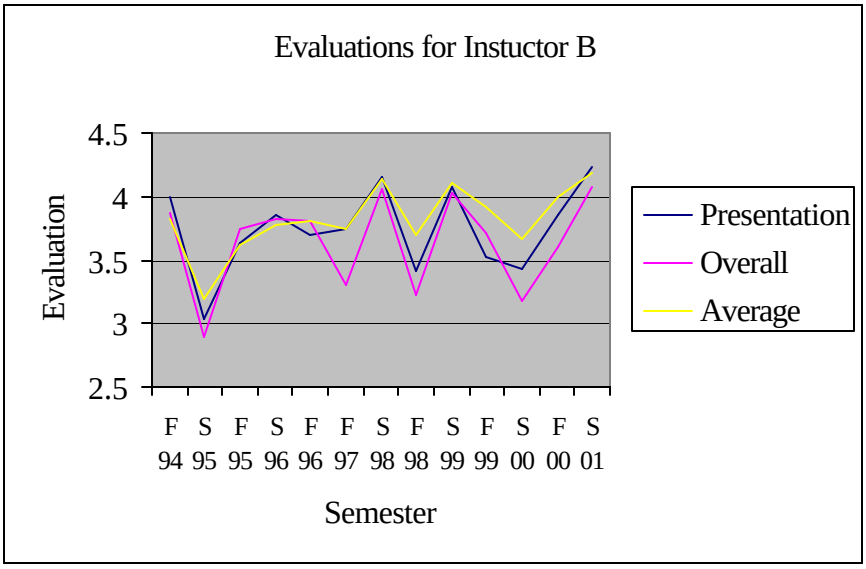


Figure 2-9. Line graph showing pertinent evaluations for Instructor B.

semesters appear to be a more consistent group, as the two worst and three best scores all occur during Spring semesters! The worst Spring (1995) was followed by a sharp increase towards the most consistent period of evaluations, corresponding to the first use of PowerPoint presentations. Finally, after a particularly bad Spring 2000, the scores have increased to the highest values, corresponding to the increased use of the web.

The data for Instructor C are plotted in Figure 2-10. Although four semesters is too short an evaluation period for any significant interpretation, the dominant features of this graph are the increase then decrease and leveling off of the evaluations. This reflects what was observed above for both Instructors A and B.

The two semesters for Instructor D show a dramatic increase in evaluations as he incorporated a great deal of technology into the class.

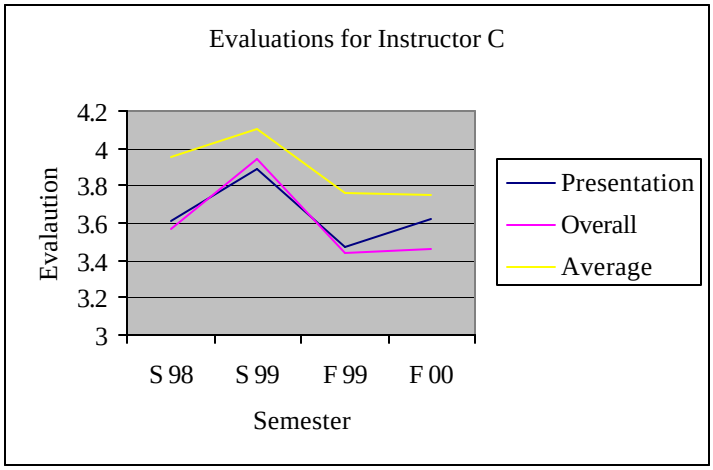


Figure 2-10. Line graph showing pertinent evaluations for Instructor C.

Finally, the data for Instructor E (Figure 2-11) reflect no significant trends. In particular, it should be observed that one evaluation increased, one decreased and one stayed the same, in the Spring 2001 semester when web use was incorporated!

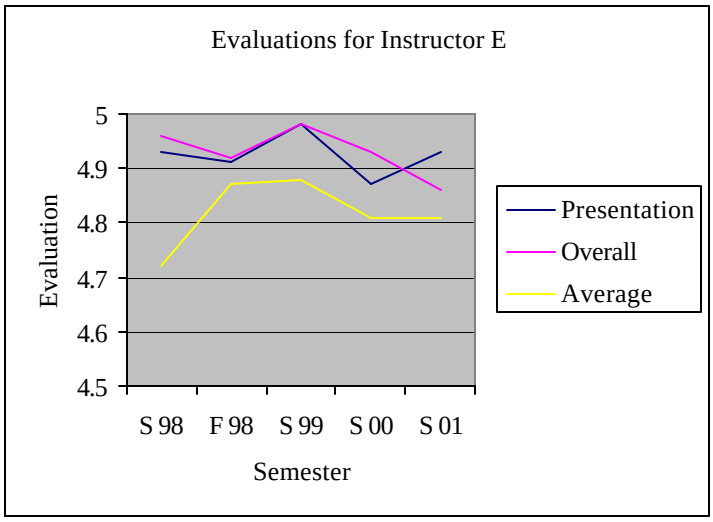


Figure 2-11. Line graph showing pertinent evaluations for Instructor E.

In addition to the numerical evaluation, students are encouraged to provide written comments on anything in the course. The comments, written since Fall 1997, have been examined for any comments about the presentation and/or use of technology.

Rather than present all the comments, a summary will be provided. PowerPoint was the most discussed and polarized topic of interest. Among instructors who used PowerPoint presentations, there were 58 comments that specifically addressed this application. 28 of these were favorable, and 30 definitely unfavorable.

While many of the comments were short and expressed only positive or negative feelings, certain ones were more detailed and offer more insight into why the students responded as they did.

A number of students commented on the notes associated with PowerPoint presentations (typed exactly as the students wrote them).

- effective use of computer generated slides. The lectures, therefore, were made more understandable, especially for those students who purchased the photocopied lecture notes.
- it is easy to read and take notes.
- I liked PowerPoint because it clearly presents the information in an organized format.

The "extra" attributes of computer presentations were noted by a number of students:

- I like the slides he uses and layers them instead of showing them all at once. Excellent teaching skills.

- I liked the movie clips.

The negative comments on the approach could be broadly separated into three categories. First of all, the speed with which instructors went through the slides was a frequent complaint:

- You should work out problems when presenting new material instead of reading the solutions on the overhead. Practice problems should be given for all chapters. Use of the computer is efficient yet at times you go too fast and the class is unable to fully grasp the materials.

A number of students felt that the class became more monotonous when computer presentations were used:

- Maybe do more chalk board next time. The computer is great, very neat, but it doesn't really grab your attention.
- The use of computers really made this class boring.

Finally, a number of students felt that use of the computer reduced the instructor's spontaneity and led to a certain dependence:

- his one weakness that is detrimental to his teaching is the use of the computer. The computer should be a tool to provide a visual representation of the material, not a tool to become dependent upon.
- Instructor relied too much on slide show.
- Dr. X should step away from his machine and go to the board and show how the work is done.

- I don’t believe the computer is able to show us everything. I think … should bring in the stick models. And use the chalkboard…we would see every step.

Opinions of students of instructors who did NOT use the chalkboard were much more consistent: twenty-six comments of which only one was in favor of computer use (No computers used so can't see well from the back.)

Varied use of the web was also addressed by 72 students, most of whom were positive (only two who said it was of no or little use). Particular comments addressed extra review questions (42 students) and posted notes (22 students). One student pointed out one disadvantage:

- Liked the information on the website, wish I could also get that information from the instructor when I didn’t have access to a computer.

2.5 Discussion and Conclusions

Student opinions concerning the use of various aspects of technology in the classroom have been examined using specific questionnaires (offered at the start and end of semesters) as well as numerical and subjective evaluations. Although it is often tempting to get highly specific and worry about opinions of individual students, only general conclusions can validly be drawn.

The student body at the University of Houston is now computer literate and experienced. They are not averse to the use of computer technology in and out of class, but they are sufficiently aware to believe that there are “right” and “wrong” ways to use it. Websites that offer extra questions, class notes etc. are almost unanimously approved

by the students. On the other hand, use of computer presentations in class, particularly those developed using PowerPoint, is a more "controversial" issue. While many students are against such a teaching approach, these negative feelings do not appear to be insurmountable. Most instructors showed an increase in evaluations upon using such presentation methods, but the increases were short-lived. By matching the numerical trends with student written comments, one can postulate that instructors might become too familiar with their PowerPoint slides, leading to an increase in their rate of presentation and also their (at least, perceived) dependence on the slides as well as a lack of "fresh" and "spontaneous" presentation of materials.

In summary, students are open to the use of computers and related technologies in their chemistry classes. Anything provided on the website appears to be a positive experience, and e-mail contact between students and faculty is essential. Computer lecture presentations can be well-received but attention must be paid to maintaining some level of spontaneity in class.

CHAPTER 3

GRADES

3.1 Introduction

Grading at UH is done using a common scale, based on exams given to all sections. At the end of the semester, all of the faculty decide upon any variations to the scale (a "curve"). As a result, the grades of a particular section within a semester are very reflective of the test performance of that section relative to the other sections. In addition, given the relative continuity of the instructors, the grading standards from one semester to the next are fairly consistent. Given both of these factors, an analysis of grade distributions, and any variations thereof, should provide a useful way to analyze the results of any changes in curriculum and teaching methods.

3.2 Grades and Grade Distribution Since 1990

The grade distribution (in percent) for the Fall Sections of 1331 from 1990 to 2000 and the Spring Sections of 1332 from 1991 to 2001 are given in Tables 3-1 and 3-2, respectively. These semesters were chosen to develop the fundamental data as they are the "main-stream" courses, with the highest enrollment. The "off-semester" classes (Spring 1331 and Fall 1332) contain a high percentage of students who are taking the class for the second time, thus introducing extraneous factors into the grading analysis. It would be appropriate, therefore to group on- and off-semester averages.

Table 3-1. Grade Distribution for Fall Sections of CHEM 1331 from 1990 to 2000

	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F	W
1990	5	4	6	11	10	11	16	4	4	4	3	10	13
1991	4	1	2	18	4	4	25	2	2	11	5	9	13
1992	5	3	3	6	6	8	13	3	3	6	6	16	22
1993	8	9	8	8	6	6	8	1	4	5	1	15	21
1994	4	4	5	8	8	10	9	4	6	5	3	12	21
1995	4	4	5	7	9	9	6	5	6	4	3	18	22
1996	4	4	5	7	7	9	11	7	7	4	2	16	17
1997	4	5	6	7	7	8	9	6	5	5	2	17	20
1998	5	5	5	8	7	8	9	6	4	6	3	15	18
1999	5	3	4	5	7	7	7	5	5	5	3	20	24
2000	6	5	6	6	8	7	9	6	5	6	2	18	16

Table 3-2. Grade Distribution for Spring Sections of CHEM 1332 from 1991 to 2001

	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F	W
1991	4	4	7	9	11	11	15	3	5	6	0	17	6
1992	6	4	6	6	9	12	9	7	5	5	4	10	18
1993	5	6	6	9	10	10	13	4	4	3	2	11	17
1994	1	3	5	6	11	9	11	5	5	5	5	18	15
1995	4	4	5	5	8	9	8	6	4	5	4	15	22
1996	2	2	3	5	6	8	8	6	4	4	4	15	33
1997	2	3	5	7	7	8	11	9	8	5	4	17	14
1998	5	7	6	7	7	10	9	7	7	7	3	14	9
1999	7	4	7	10	9	10	11	6	6	5	3	10	11
2000	9	6	7	6	10	7	10	9	5	5	3	14	10
2001	10	9	10	8	9	7	9	7	2	5	2	8	13

The data from Table 3-1 are plotted in Figure 3-1. This is a rather confusing picture, primarily due to the complications of assigning + and – grades. Accordingly, Figure 3-2 shows the same data, but simply in terms of letter grades in which, for example, all the B+, B and B- grades are combined. Figures 3-3 and 3-4 are the same representation for the grades for Spring 1332.

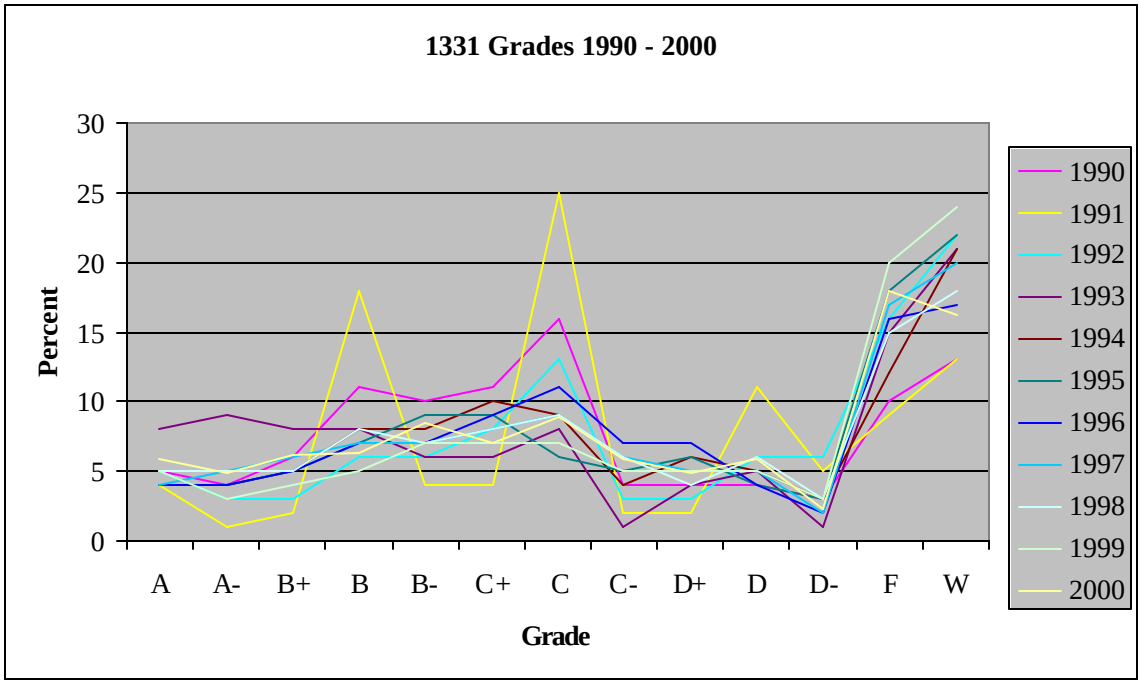


Figure 3-1. Grade distribution in percent for 1331 Fall sections, 1990 – 2000.

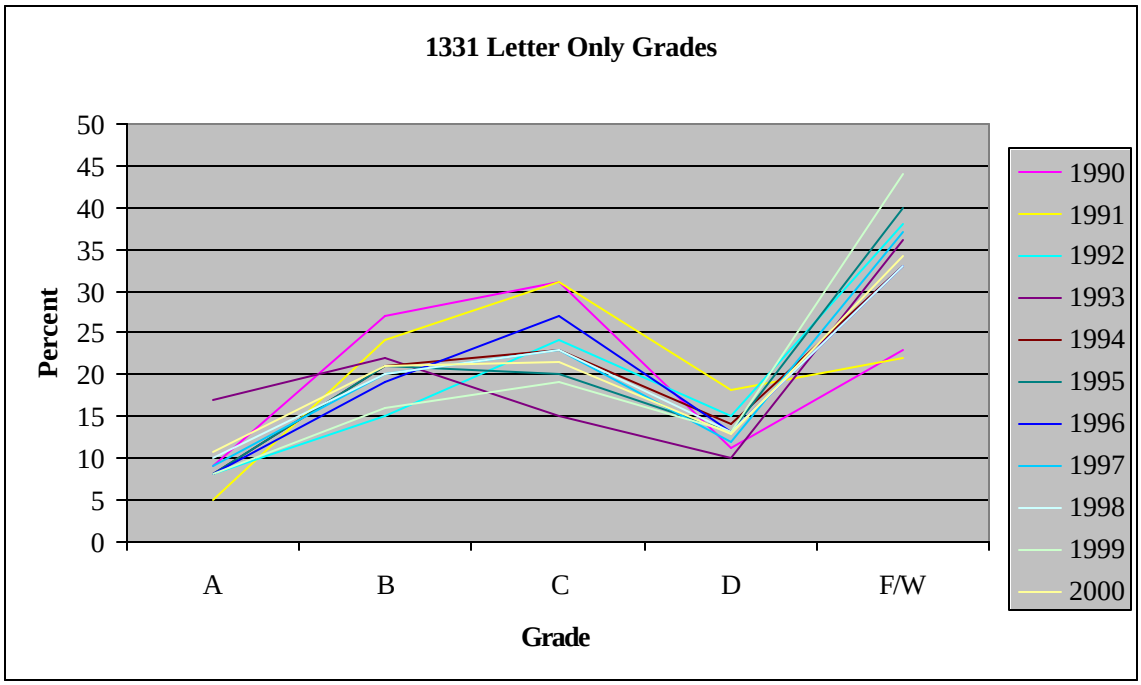


Figure 3-2. Letter distribution in percent for 1331 Fall sections, 1990 – 2000.

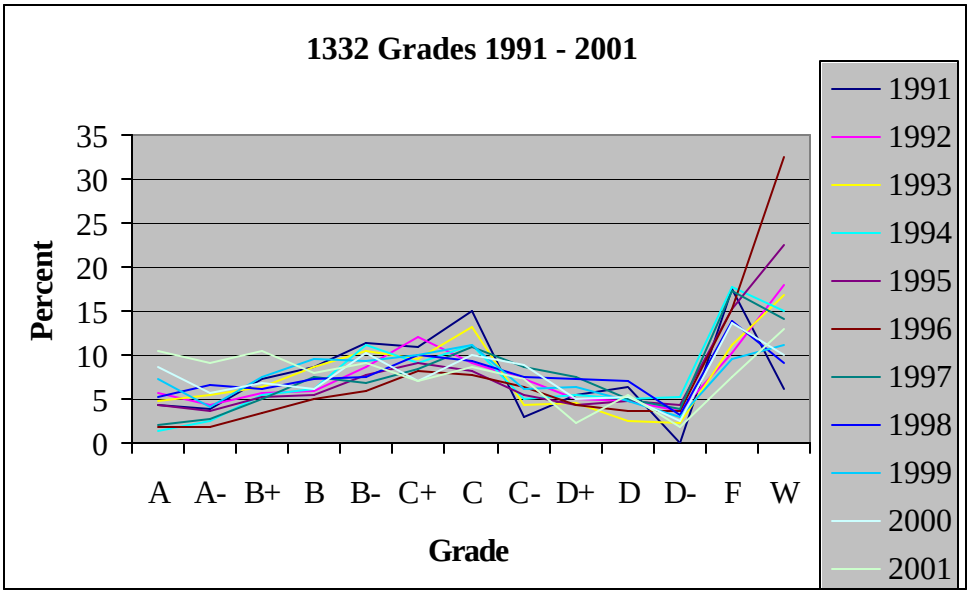


Figure 3-3. Grade distribution in percent for 1332 Spring sections, 1991 – 2001.

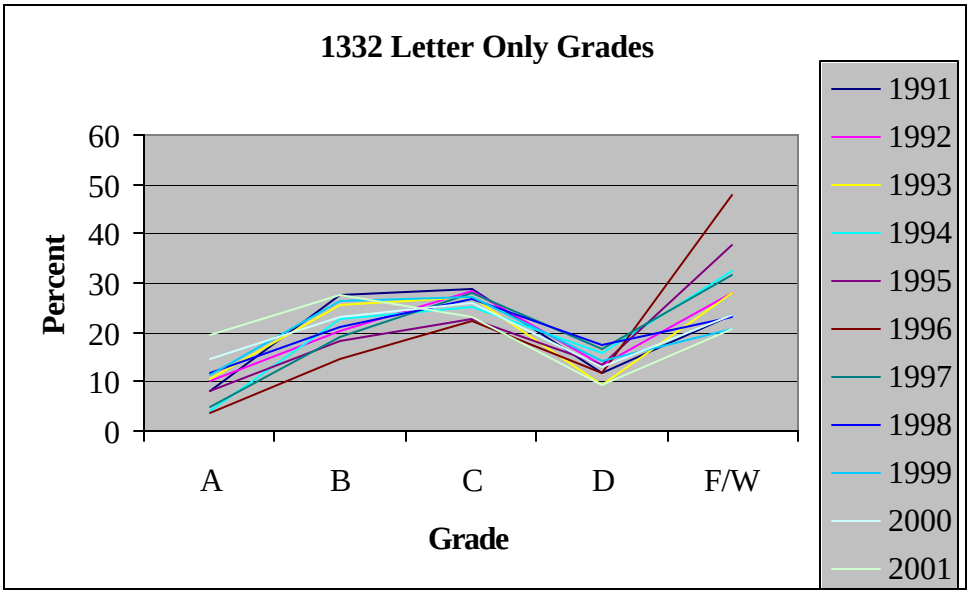


Figure 3-4. Letter distribution in percent for 1332 Spring sections, 1991 – 2001.

Examination of Figure 3-2 shows that the typical grade distribution is one in which the passing grade numbers are such that A < D < B < C – in other words, almost a normal distribution that is skewed a little towards the lower grades. The only semester in which this is not the case is Fall, 1993. This anomalous semester (in which the grades are inexplicably much higher) will be ignored in the calculation of mean values (see below).

In general, the combined F/W grades are much higher than each individual passing grades, ranging from 33 to 44% since 1992. It is noteworthy that the number of such grades increased dramatically between 1991 and 1992. This change was due to the introduction of multiple exam versions (three versions of each exam randomly distributed among the students). Accordingly, data before 1992 will not be included in any further discussion. [*N.b*. It was included in this part of the discussion for the sake of completeness and also to indicate how a change in course structure can dramatically affect the grade distribution!]

The 1332 grades are much more normally distributed in that the average proportion of A's approximates that of D's and the number of B's approximates the number of C's. In general, the proportion of F/W grades is less than observed in 1331, with the exception of 1996.

In order to reduce the level of detail present in grade distributions, and more efficient way of comparing grades is to calculate the average. Rather than using a letter grade, this will be calculated as a GPA based on the letter grades without the signs:

Average = {[(% of A) x 4] + [(% of B) x 3] + [(% of C) x 2] + [(% of D)]} / 100

The GPA values for each semester, taken from the data in Figures 3-2 and 3-4, are shown in Table 3-3 for 1331 and 1332, respectively. These will be referred to as "Semester Average" values from now on.

Table 3-3. Average Grade (as "GPA") for 1331 Fall and 1332 Spring Semesters

Academic Year	1331 Fall	1332 Spring
1990/1991	1.9*	1.85
1991/1992	1.72*	1.71
1992/1993	1.4	1.81
1993/1994	1.74*	1.49
1994/1995	1.55	1.46
1995/1996	1.48	1.15*
1996/1997	1.56	1.50
1997/1998	1.54	1.81
1998/1999	1.59	1.93
1999/2000	1.31	1.92
2000/2001	1.61	2.16

The overall average and standard deviation since the 1990 academic year for Fall 1331 classes are 1.51 ± 0.10 and for Spring 1332 classes are 1.76 ± 0.23. These values will be referred to as the appropriate "Course Average" from now on.

It is fairly fruitless to try to derive too much from the data for every class. This discussion is more intended to generate some "numbers" that may be used to analyze the effectiveness of individual instructors. It is worth noting, however, that (with one or two exceptions) both the 1331 and 1332 numbers have increased on average over the last four to five years. This increase is much more notable in 1332 compared to 1331. This corresponds to the introduction of "technology" into the curriculum generally.

3.3 Grades for Individual Instructors

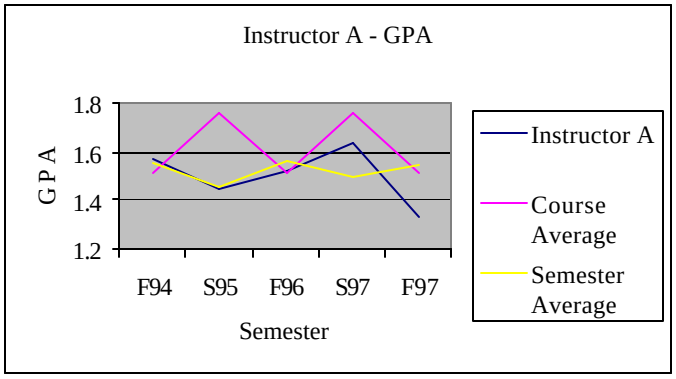
In order to determine how effective the introduction of technology has been, the grades for the sections taught by the same instructors as were the subjects in Chapter 3 will be analyzed.

The grade distributions and GPA values for Instructors A, C and E are listed in Table 3-4. The GPA values are plotted in Figure 3-5. In each section of the Figure, the "Course Average" (mean value for all 1331 or 1332 semesters since Fall of 1990) and "Semester Average" (average GPA for all sections of that particular course in that specific semester) are included for comparison purposes.

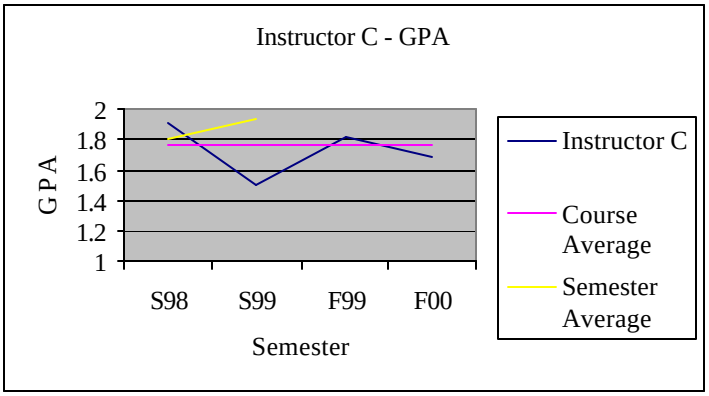
Instructor A did not use computers in any way for the first two semesters. He then switched to PowerPoint. As was noted with the student evaluations in the previous chapter, the GPA of his sections increased initially after use of PowerPoint, but then

Table 3-4. GPA Values for Instructors A, C and E

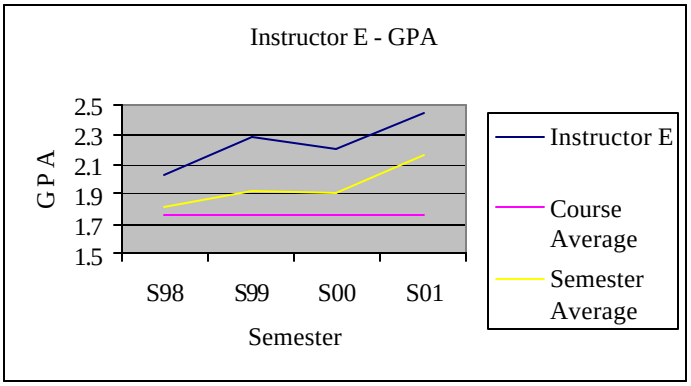
Semester/Course	A	B	C	D	W/F	"GPA"
Instructor A						
F 94 / 1331	8	19	24	19	30	1.567
F 96 / 1331	7	15	32	15	31	1.522
F 97 / 1331	7	18	19	13	43	1.331
S95 / 1332	7	18	24	14	37	1.447
S97 / 1332	6	23	26	18	27	1.633
Instructor C						
S98/1332	14	26	21	16	23	1.907
S99/1332	9	18	21	21	32	1.5
F99/1332	11	26	24	13	26	1.823
F01/1332	9	21	28	13	28	1.689
Instructor E						
S98/1332	13	23	32	19	13	2.034
S99/1332	15	32	32	10	12	2.279
S00/1332	15	28	30	14	12	2.198
S01/1332	25	30	23	8	14	2.45



(a) Instructor A



(b) Instructor C



(c) Instructor E

Figure 3-5. Line graphs showing GPA values over semesters for (a) Instructor A, (b) Instructor C, and (c) Instructor E.

declined. Although the minimal data available preclude detailed analysis, it should be noted that the 1332 class GPA improved to a greater extent than was observed for his sections of 1331.

Instructor C taught 1332 using PowerPoint each semester – Spring for the first two occasions and Fall for the second two. In each case, the first section of each pair had the better GPA, although the difference was more significant between the first and second Spring semester than between the first and second Fall semesters. With the exception of his second semester, his grades have been close to the course average.

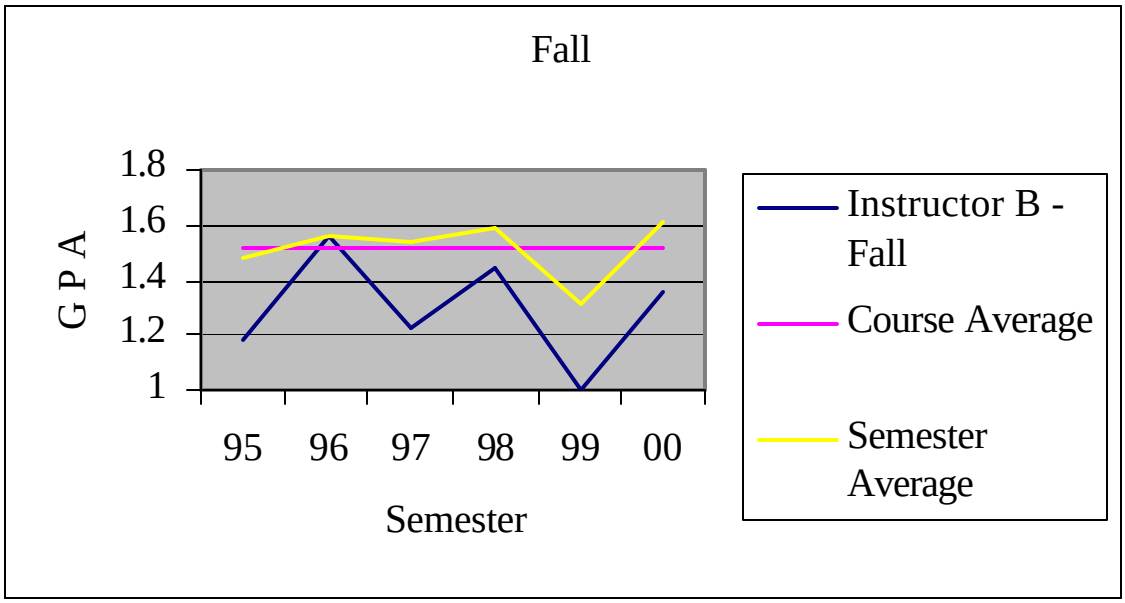
Instructor E does not use PowerPoint but did make extensive use of the web in the Spring 2001 semester. The GPA of this class was much higher than that of previous classes.

Instructor B is considered separately as he has the most sections. The grade distributions and GPA for his sections are shown in Table 3-5 and the GPA values are plotted in Figure 3-6. Instructor B has taught 1331 since 1993 in both the Fall and Spring semesters. He began using PowerPoint presentations in the Fall of 1995, and has made variable use of the web since then. In Fall 2000 (unsuccessfully) and Spring 2001 (more successfully), he ran his class using WebCT™. The data for these semesters are tabulated and plotted separately.

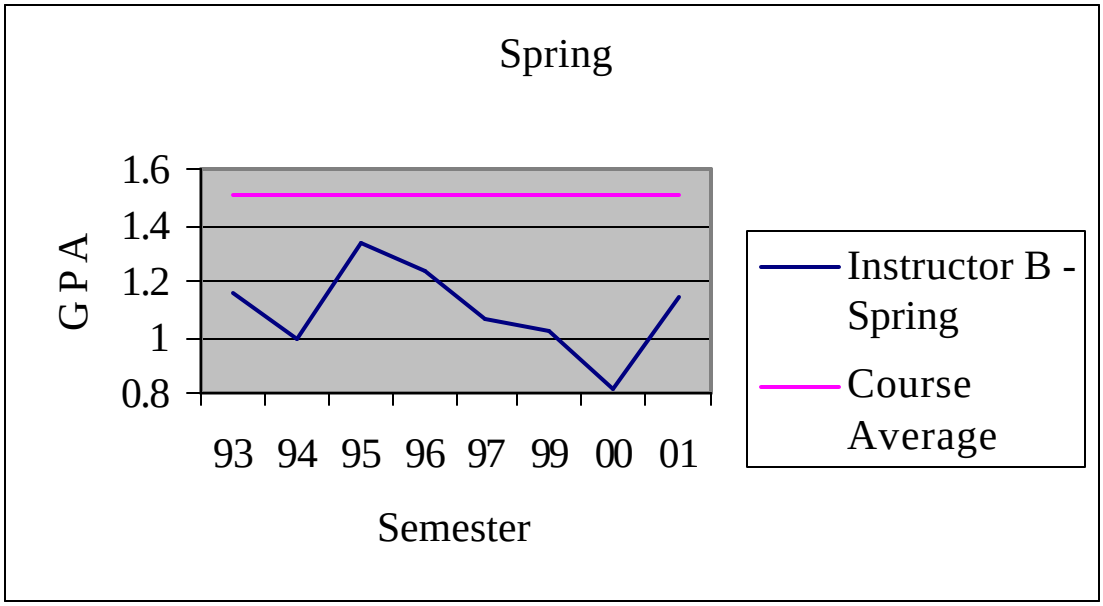
Generally, the GPA for Instructor B's sections are lower than both the Course and (where available) Semester averages. In his Fall classes, the GPA has a zigzag pattern to it, with significant increases followed by significant decreases. The latter have been greater than the former so there is a slight downward trend overall.

Table 3-5. GPA Values for Instructor B

Semester/Course	A	B	C	D	W/F	"GPA"
Fall						
1995	7	12	19	15	47	1.181
1996	11	19	23	11	36	1.566
1997	8	12	22	10	48	1.221
1998	9	16	23	15	38	1.444
1999	6	12	13	13	56	0.998
2000	8	17	19	14	42	1.356
Spring						
1993	5	15	20	13	48	1.158
1994	5	10	19	14	53	0.993
1995	7	15	24	14	41	1.335
1996	7	13	20	16	44	1.229
1998	7	11	14	18	50	1.06
1999	3	11	20	19	48	1.023
2000	3	9	15	13	60	0.81
2001	3	10	29	14	43	1.144



(a) Fall GPA



(b) Spring GPA

Figure 3-6. Line graphs showing GPA values for Instructor B for (a) Fall and (b) Spring.

The Spring numbers are consistently lower than the course average, although this is to be expected given the high proportion of "retakes" and anecdotal evidence concerning the lower quality of "off-semester" students. After a sharp increase in GPA in Spring 95 (notably the semester before using PowerPoint full-time), the value has consistently decreased. This trend stopped this last Spring, when the best GPA value in five years was obtained.

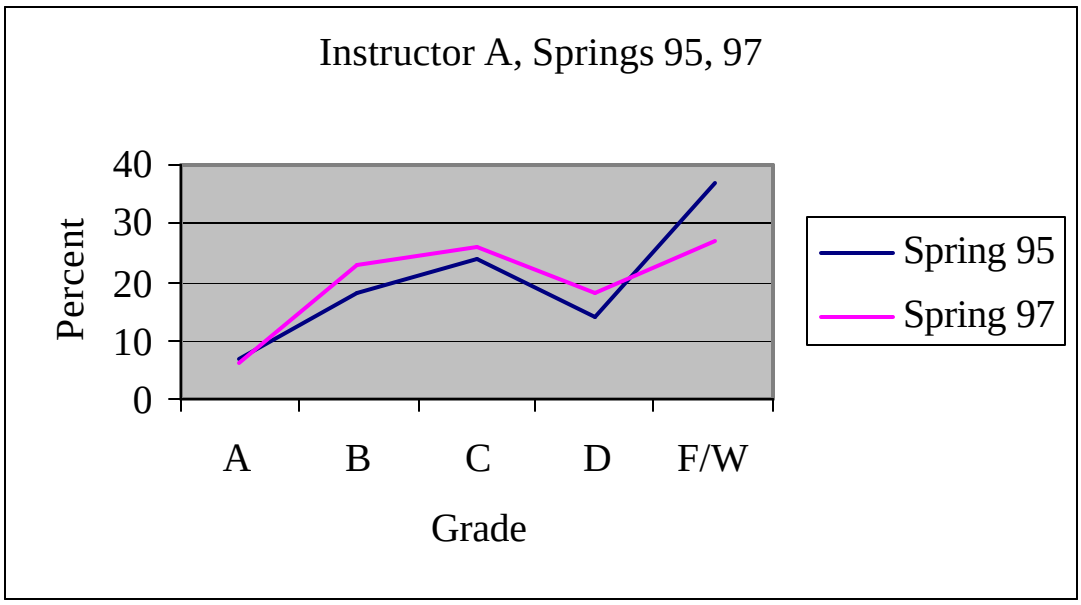
Generally, the GPA data discussed in this section can be summarized in three broad observations. Generally, use of PowerPoint seems to result in an increase in GPA. However, this increase is short-lived, the GPA decreasing within 2 semesters of initiating use of the approach. In the two recent cases where a substantial increase in web use was developed, the GPA also increased dramatically.

In order to examine these three factors more closely, the actual grade distributions may be used. It is not worth looking at these for every semester as the variations are too extensive and usually statistically insignificant. However, it is worth examining these specific changes to see whether they are associated with the entire grade spectrum or particular groups of students.

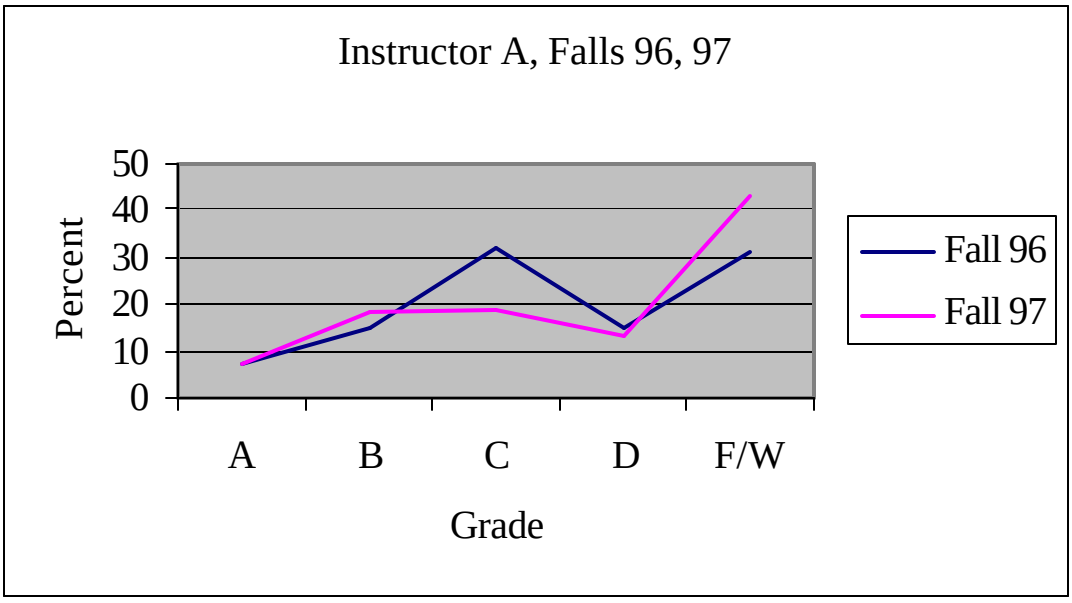
To this end, the following pairs of grade distributions were examined, which are shown graphically in Figure 3-7.

Instructor A, 1332 in Spring of 1995 and 1997, the GPA for which showed an increase after the introduction of PowerPoint (Figure 3-7a);

Instructor A, 1331 in Fall of 1996 and 1997, in which a dramatic decrease in GPA was noted (Figure 3-7b);



(a)



(b)

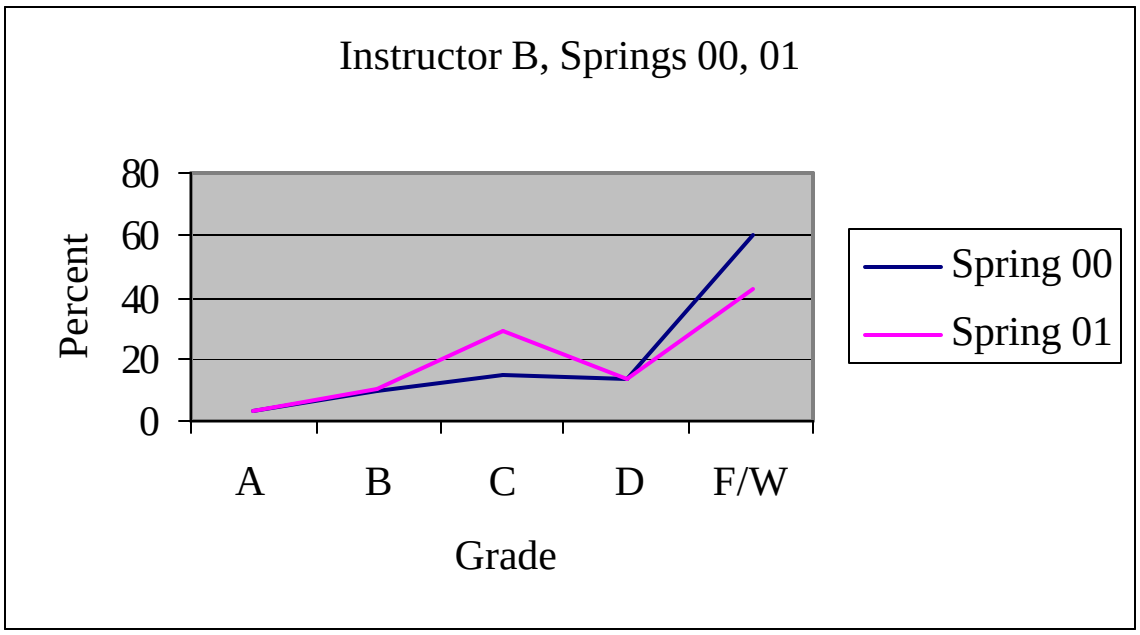
Figure 3-7. Grade distribution comparisons, (a) Instructor A, 1332 in Spring semesters of 95, 97; (b) Instructor A, 1331 in Fall semesters of 96, 97.

Instructor B, 1331 in Spring of 2000 and 2001, in which a dramatic increase in GPA was noted, after the increased use of the web (Figure 3-8a);
Instructor E, 1332 in Spring of 2000 and 2001, in which a dramatic increase in GPA was noted, after the increased use of the web (Figure 3-8b).

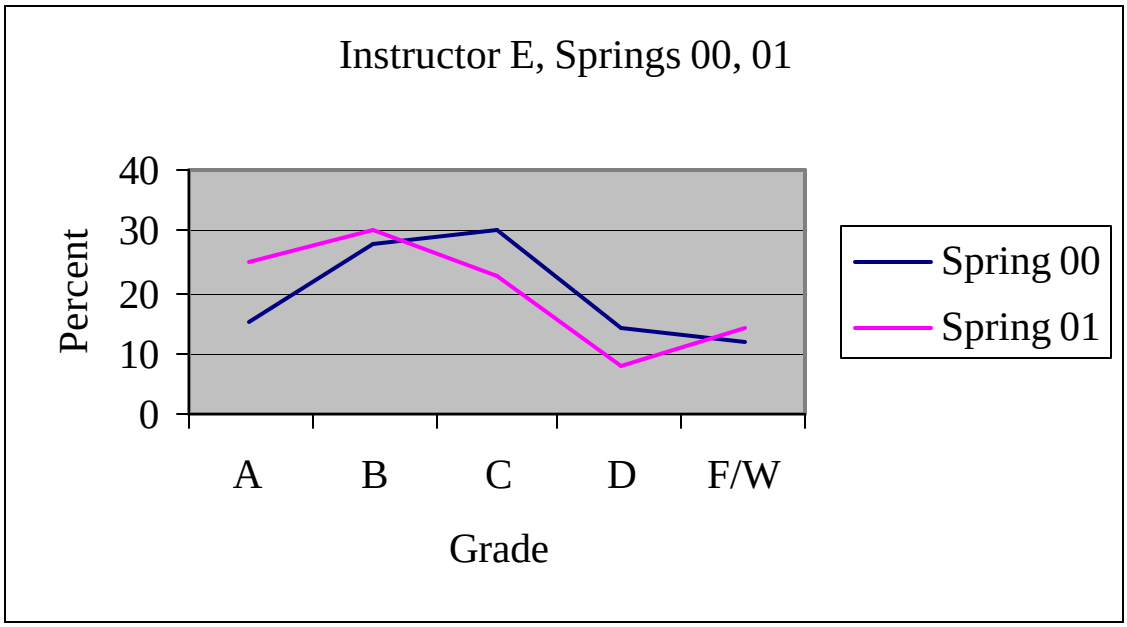
These comparisons show some consistency with each other. The first three imply that any change affects the number of F/W grades. Thus, introduction of PowerPoint by Instructor A and heavy web use by Instructor B decreases the proportion of F's and W's, while the decrease in GPA noted for Instructor A's sections after two years of PowerPoint was due to an increase in the F/W grades. However, when Instructor E used the web extensively, his proportion of F's and W's remained constant!

In a similar fashion, the first three comparisons have approximately the same proportion of higher grades but changes in the lower, C and D, grades. Thus, when Instructor A began to use PowerPoint, the lower number of F grades translated into a higher proportion of B, C and D's. Conversely, when Instructor A's GPA decreased, and the F/W increased, this was accompanied by a noticeable decrease in the number of C grades. When Instructor B began to use WebCT™ effectively (thus making major use of the web), the drop in F and W grades predominantly was reflected in an increase in the proportion of C's.

As might be expected given the small change in F/W grades, however, the higher GPA in Instructor E's class after introduction of the web was due to a shift in lower grades to higher grades. Thus, the proportion of C and D grades decreased, that of B



(c)



(d)

Figure 3-8. Grade distribution comparisons, (a) Instructor B, 1331 in Spring semesters of 2000, 2001, (d) Instructor E, 1332 in Spring semesters of 2000, 2001.

grades stayed approximately the same, while the relative number of A grades increased by more than 60%.

As a partial contrast to this apparent lack of consistency, it should be noted that Instructor E had a much lower proportion of F and W grades. A tentative conclusion, therefore, might be as follows. In general, when incorporation of technology affects grades, it generally affects the average to poor students. If a positive effect, then fewer students withdraw or fail the class; if a negative effect, then more students withdraw or fail. There are obvious limits to the extent of any such improvement.

CHAPTER 4

CONCLUSION

It is dangerous to draw too many specific conclusions from any retrospective investigation of a program like this. No attempt at incorporating any extra controls into the classroom was possible. Thus, comparisons of data from one semester to the next do not take into account changes in student quality and aptitude, while comparisons of sections within the same semester cannot account for factors due to different instructors and even time at which the classes are offered. Nevertheless, the data and analysis attempted here show some general trends and provide some possibly valuable information.

The student body at the University of Houston should now be described as computer-literate and enabled. A sizeable majority are comfortable with use of computers in and out of the classroom. However, their feelings about different applications vary as does the effectiveness thereof.

The student body has become virtually unanimous in approval of web use outside of class. They like the idea at the start of the semester, and they increasingly are positive about their experiences with it at the end of the semester. Of the possible ways in which the web is used, course information such as syllabus and news is fairly well received and even more students like the idea of class notes being posted. However, the most positive

student responses are associated with a perception of "getting something extra," when review sheets and supplemental questions are posted.

Such activities also affect grades positively. Each time that the web was used to a large extent in a class, the average grade increased, usually by increasing "retention" in the class.

One aspect of web use that has declined in perceived popularity has been the administering of exams. Students have liked the idea of this less over the years. The only true experiment with giving truly graded exams in this way, however, has met with positive responses from the students. Again, however, this is an example of "getting more" as the exams have been "make-up" tests.

Another aspect of technology that has received more and more positive student responses has been the use of e-mail. Students appreciate this easy and relatively-anonymous way to contact their instructor. It is difficult to assess whether use of e-mail has any direct effect on grades, however.

In contrast to web use, introduction of technology into the classroom in the form of computer presentations has had mixed success. There is a definite polarization of the student body over their thoughts on this issue – some like it, some hate it! The proportion of the latter appears to have increased over the time-frame of this study.

Some definite trends have emerged from the analysis of results when computer presentations have been introduced. There is a greater degree of student approval when the presentations are more than simply slides. Appreciation of the instructor's presentation and the average grades do appear to increase when the instructor first

"switches" to using the method. However, when examined over a period of time, both student evaluations and grades tend to decrease.

More information may be derived from examination of student comments. Many have noted that the instructors tend to become dependent on the presentation. Others have pointed out the increased speed with which the instructor goes through the slides. Finally, the number of comments that mention tedium in class is notable.

One possible explanation for these observations is that instructors will focus on the quality of the presentation when first using it, as well as being aware of student reaction. After repeated use, however, "familiarity will breed contempt" and this focus and awareness will decrease. While this is a fairly common complaint of students with overhead presentations, the reduced effort involved with changing a PowerPoint slide compared to an overhead quite possibly exacerbates the problem.

In summary, instruction of General Chemistry appears to benefit substantially when web pages that provide information are used and when instructors encourage use of e-mail. The benefits of using computer presentations in class are less well-defined. It is probably still a good idea to offer sections that do and sections that do not use this method. For instructors who do develop computer presentation, efforts should be made every semester to maintain some level of spontaneity in the classroom.

BIBLIOGRAPHY

No specific references have been used in this thesis as one would either be woefully inadequate or the list would be longer than the thesis itself. There are numerous reports of ways in which technology may be used in the teaching of General Chemistry.

The best source is *The Journal of Chemical Education* (http://jchemed.chem.wisc.edu/). Each issue has a section on teaching with technology that often contains useful applications for General Chemistry.

Two issues of *The Journal* have focused on the area:

Volume 76, Number 5, May 1999

Volume 77, Number 2, February 2000

WebCT™ is a comprehensive web-based program suite for class management. Further details may be found at the website, http://www.webct.com/